(12) UK Patent Application (19) GB (11) 2 277 200 (13) A

(43) Date of A Publication 19.10.1994

(21) Application No 9307912.7

(22) Date of Filing 16.04.1993

(71) Applicant(s)
British Aerospace Space Systems Limited

(Incorporated in the United Kingdom)

Gunnels Wood Road, STEVENAGE, Hertfordshire, SG1 2AS, United Kingdom

(72) Inventor(s)
Ian Honstvet
Neil Dunbar

(74) Agent and/or Address for Service
Paul Blaise Rooney
British Aerospace Public Limited Company, PO Box 87, Corporate Intellectual Property Dept, Lancaster House, Park East, Farnborough Aerospace Centre, FARNBOROUGH, Hants, GU14 6YU, United Kingdom

(51) INT CL^5
H01Q 1/42

(52) UK CL (Edition M)
H1Q QKJ
B5N N0526 N0702 N0708 N1702 N175 N177 N178 N18X N180 N181 N195 N196 N206 N207 N21Y N223 N225 N244 N246 N2712 N2734 N37X N372 N395 N400 N466 N478 N491 N500 N501 N502 N55X N550 N552 N564 N569 N57Y N570 N589 N593 N70X N71X N71Y N716 N726 N77X N778
U1S S1842 S2203

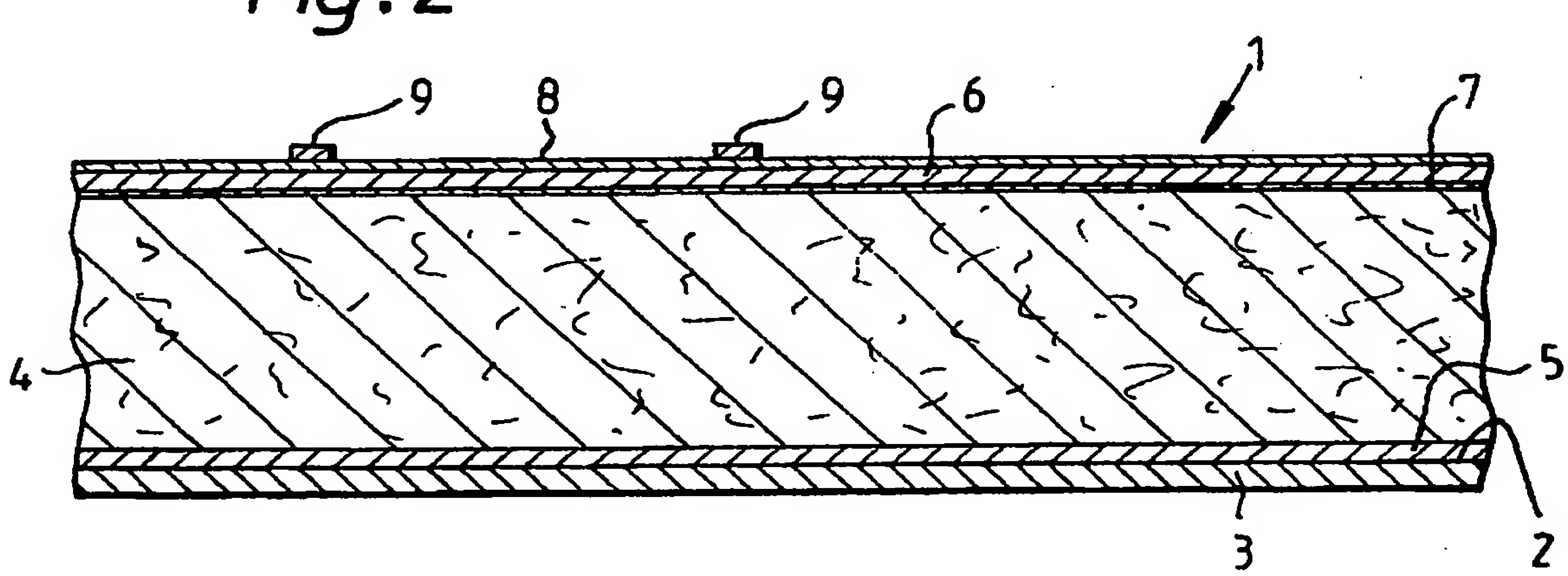
(56) Documents Cited
GB 2228142 A EP 0529776 A1 EP 0489531 A1
US 4479131 A

(58) Field of Search
UK CL (Edition L) H1Q QKJ QKL QKN
INT CL^5 H01Q
Online databases:WPI

(54) A cover for a spacecraft antenna

(57) A multilayer, thermally resistant, at least partially flexible, substantially radio frequency transparent, cover (1) for a spacecraft antenna is made up of an insulating layer (4) of glass fibre which is sandwiched between a first layer (5) of polymer film which is directed towards the antenna (3) and a second layer (6) of non-conductive polymer film on the outermost surface of the insulating layer (4). The second layer (6) is, or is rendered, opaque to visible and infrared radiation and carries an electrically conductive coating layer (8) on its outermost surface and means (9) for electrically grounding the coating layer (8). The polymer film layers (5, 6) may be made of polyimide or glass fibre and quartz material, conductive coating (8) may be Germanium or Indium-Tin Oxide and the second layer (6) may be made opaque by a layer of paint or the polyimide layer being loaded with a pigment.

Fig. 2



GB 2 277 200 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

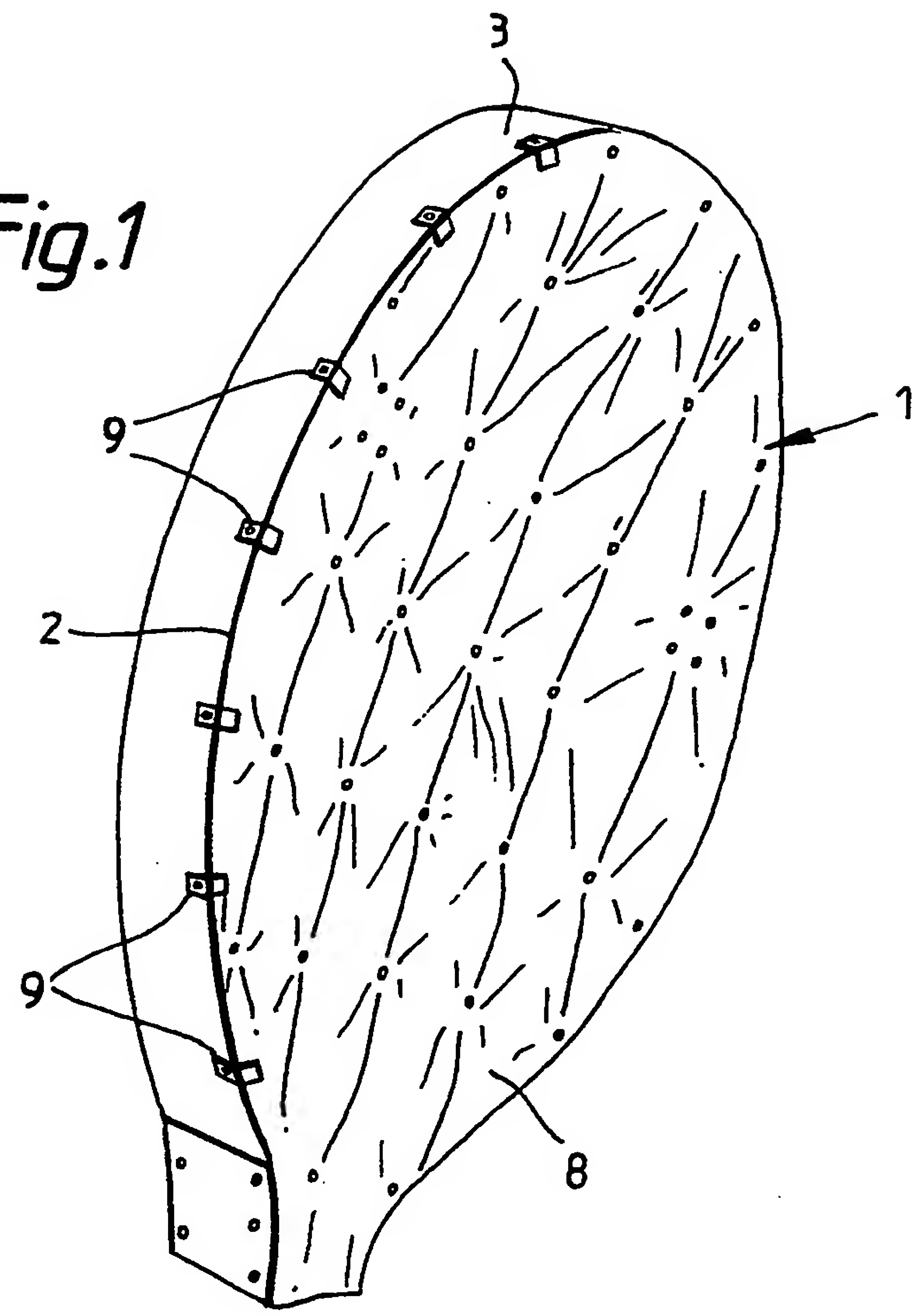


Fig.1

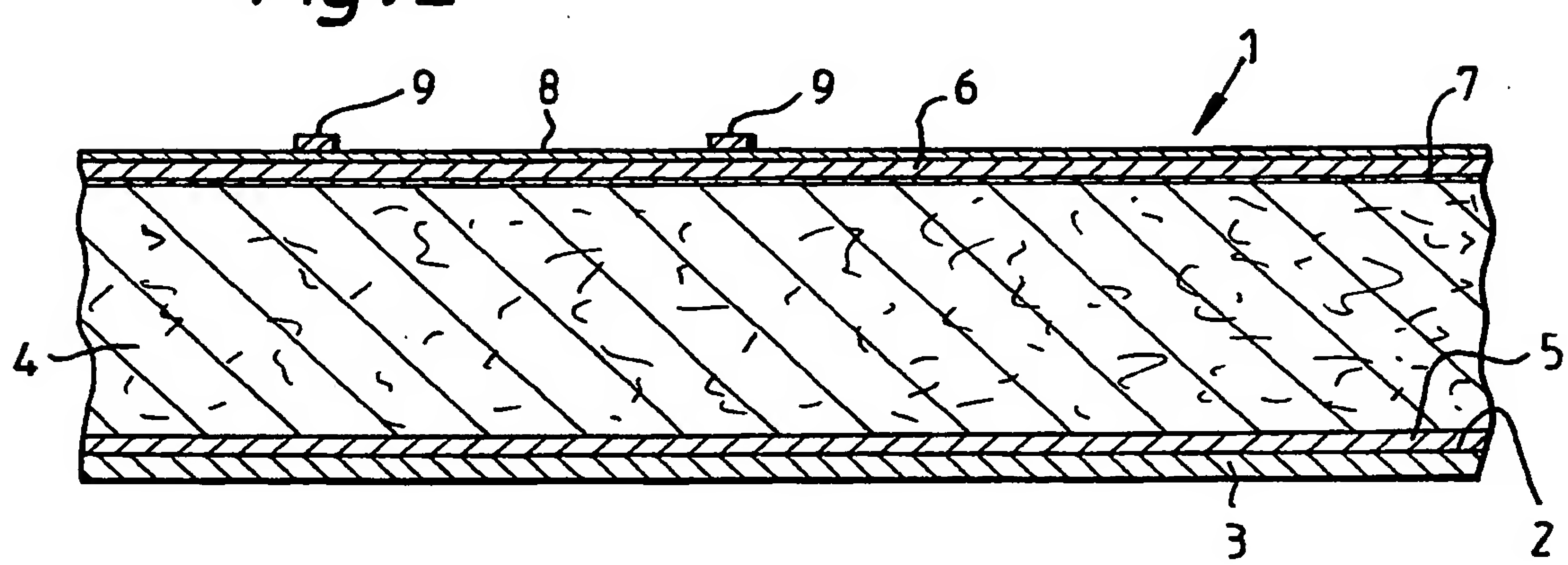


Fig.2

A COVER FOR A SPACECRAFT ANTENNA

This invention relates to a cover for a spacecraft antenna and particularly, but not exclusively, to a multilayer, thermally resistant, at least partially flexible, substantially radio frequency transparent cover for at least an active surface of a spacecraft antenna.

Spacecraft antennas in use undergo a wide variation in temperature which can lead to undesirable thermal distortions. There is thus a need for a thermal cover or shield designed to control the temperature of a spacecraft antenna and thereby reduce the thermal distortion.

Three conventional types of thermal cover have been proposed. A first of these involves insulating the non-active surfaces of the antenna only and employing thermally resistant paint on the active surface of the antenna. This approach results in relatively poor thermal control. For example a spacecraft antenna reflector treated in this way would still experience a variation of temperature as wide as 250°C. This results in high thermal distortion which is even more noticeable if the antenna has a complex construction such as is the case with multi shell reflectors.

A further known technique is to suspend a metallised polymer film over the active face of the spacecraft antenna with the metal layer etched into a frequency selective pattern operative to allow radio frequency signals to pass through. Whilst this system has better

thermal performance it has the disadvantages that the thermal performance is degraded by the metal removed from the etching set, the shield or cover requires a relatively heavy support to avoid imposing thermal distortion loads on the antenna, the shield is expensive and the large metal content in the antenna field of view gives rise to a significant risk of signal distortion or attenuation due to passive intermodulation.

A third known system involves suspending a non-metallised opaque film over the active surface of the antenna. Whilst this latter technique avoids the problems associated with the etched metallised polymer technique it does so at the expense of a greatly reduced thermal performance and therefore higher antenna temperature ranges and thermal distortion.

There is thus a need for generally improved cover for a spacecraft antenna which is effectively transparent to radio frequency signals but which at least minimises the foregoing disadvantages inherent in the conventional techniques.

According to one embodiment of the present invention there is provided a multilayer, thermally resistant, at least partially flexible, substantially radio frequency transparent, cover for at least an active surface of a spacecraft antenna, which cover includes an insulating layer of fibrous, non-metallic radio frequency transparent, insulating material, a first layer of

non-conductive radio frequency transparent polymer film on one surface of the insulating layer, which first layer is directed, in use, towards at least the active surface of a spacecraft antenna, a second layer of non-conductive, radio frequency transparent, polymer film on the surface of the insulating layer opposite to said one surface, which second layer is, or is rendered, opaque to visible and infrared radiation and is directed, in use, away from the at least active surface of the spacecraft antenna, an electrically conductive, radio frequency transparent, coating layer on the outermost surface of the second layer, and means for electrically grounding the electrically conductive coating layer.

Preferably the insulating layer is a mat of glass fibres.

Conveniently the first layer is made of a polyimide or glass fibre and quartz material.

Advantageously the polyimide material is KAPTON (Registered Trade Mark) and the glass fibre and quartz material is BETACLOTH (Registered Trade Mark).

Preferably the second layer is made of a polyimide or glass fibre and quartz material rendered opaque to visible or infrared radiation by a non-conductive optically opaque paint coating layer on at least one surface thereof.

Conveniently the polyimide material is KAPTON (Registered Trade Mark) and the glass fibre and quartz material is BETACLOTH (Registered Trade Mark).

Alternatively the second layer is made of polyimide material loaded with a pigment to render is opaque to visible and infrared radiation.

Advantageously the polyimide material is KAPTON (Registered Trade Mark).

Conveniently the coating layer is made of Germanium or Indium-Tin Oxide.

Advantageously the means for electrically grounding the electrically conductive layer include a plurality of strips connected to said electrically conductive layer.

Conveniently the cover includes means for attachment to an antenna.

Advantageously the attachment means are polymer studs or hook and eye tape.

According to a further aspect of the present invention there is provided a cover assembly including two multilayer, thermally resistant, at least partially flexible covers as hereinbefore disclosed for covering both the active and inactive surfaces of a spacecraft antenna.

For a better understanding of the present invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which;

Figure 1 is diagrammatic perspective view of a spacecraft antenna provided with a multilayer, thermally

resistant, at least partially flexible cover, according to a first embodiment of the present invention, and

Figure 2 is a cross-sectional view, to an enlarged scale, of a detail of the cover of Figure 1.

A multilayer, thermally resistant, at least partially flexible, coversubstantially radio frequency transparent, 1 according to a first embodiment of the present invention, as shown in Figures 1 and 2 of the accompanying drawings, is intended for use to cover at least an active surface 2 of a spacecraft antenna 3. The cover 1 includes an insulating layer 4 of fibrous, non-metallic, radio frequcny transparent, insulating material such as a mat of glass fibres. Prferably the layer 4 is in the form of a slab which is flexible and provides the thermal insulating properties for the cover. The thickness of the layer 4 is chosen to meet the thermal performance required. A suitable thickness is 25 mm. The insulting layer 4 contains no metallic materials as these would otherwise distort or attenuate the radio frequency signal.

A first layer 5 of non-conductive, radio frequency transparent, polymer film is provided on one surface of the insulating layer 5 and is directed, in use, towards at least the active surface 2 of the antenna 3. This first layer 5 is made of a polyimide material such as KAPTON (Registered Trade Mark) or glass fibre and quartz material such as BETACLOTH (Registered Trade Mark). The polymer is

selected to withstand the electromagnetic and particulate radiation environment in space and to withstand the expected temperature cycle range to which the cover will be subjected in use.

Also forming part of the cover 1 is a second layer 6 of non-conductive, radio frequency transparent, polymer film which is provided on the surface of the insulating layer 4 opposite to said one surface. Thus the second layer 6, in use of the cover 1, is directed outwardly of the cover and is most remote from the antenna surface 2. The second layer 6 is, or is rendered, opaque to visible and infrared radiation and is directed, in use of the cover, away from the surface 2 of the antenna 3.

This second layer 6 can be made in two different ways. According to a first way forming part of the present invention, the layer 6 is made of polyimide such as KAPTON (Registered Trade Mark) or glass fibre and quartz such as BETACLOTH (Registered Trade Mark) rendered opaque to visible and infrared radiation by a non-conductive optically opaque paint coating layer 7 on at least one surface thereof. Preferably the surface 7 is that directed towards the insulating layer 4. This paint can be any suitable commercially available non-conductive optically opaque paint.

According to a second way, which also forms part of the present invention, the layer 6 is made of polyimide material, preferably KAPTON (Registered Trade Mark) loaded

with a pigment to render is opaque to visible and infrared radiation. However the second layer 6 is formed the paint coating layer 7 or loading in the layer 6 prevents sunlight and infrared radiation penetrating the cover 1 and degrading the thermal performance thereof.

An electrically conductive, radio frequency transparent, coating layer 8 is provided on the outermost surface of the second layer 6. This coating layer 8 may be made of Germanium deposited thereon in any convenient manner or of any commercially available high resistance material such as Indium - Tin Oxide. This coating layer 8 provides just sufficient lateral electrical conduction path to leak the build up of electrical charge to the antenna 3 or spacecraft structure via means for electrically grounding the electrically conductive coating layer 8. This means may include a plurality of straps 9 connected to the layer 8. The electrical conductivity of the layer 8 is insufficient significantly to affect the antenna radio frequency performance. The cover 1 is attachable to the antenna surface 2 in any convenient manner such as by polymer studs or hook and eye tape (not shown).

A cover of the present invention is intended to be substantially radio frequency transparent at frequencies below 300 GHz. Preferably the required radio frequency transparent range is from 0.1 to 50 GHz and more preferably from 0.1 to 20 GHz.

The flexible nature of the cover 1 means that its outermost surface can be made undulating, as shown in Figure 1 to break up specular reflections of sunlight. This may be done by securing the cover to the antenna surface by means of rivets or the like having different lengths. Thus at one point the rivet may be short enough to secure the cover in face to face contact with the antenna surface whilst at a different point the rivet may be elongated sufficiently to support the cover at a spacing away from the antenna surface. The undulating surface produced in this way prevents the sun's rays being focussed by the cover on a feed horn for the antenna, which focussing would undesirably heat up the feed horn.

Although in the aforegoing description and in the embodiments illustrated in Figures 1 and 2, the cover has been shown as applied only to the active surface 2 of a spacecraft antenna 3, it is to be understood that a further cover 1 could be provided over the inactive surface of the antenna 3 so that the two covers 1 together make up a cover assembly for the antenna 3.

A cover 1 and cover assembly of the present invention have better thermal performance than conventional covers or shields and thereby reduces the thermal distortion of the antenna in operation. No elaborate support structure is required which avoids undue loading on the antenna and hence resulting distortion. The metallic components of the cover are kept to a minimum thereby reducing risk of

radio frequency signal interference. The cover of the invention is of relatively light weight and flexible so that it may be draped over an antenna surface without requiring to be stretched or carried on heavy expensive support structures as is conventional. This and the other constructional features of the cover of the present invention make it less expensive to manufacture than the conventional systems.

CLAIMS

1. A multilayer, thermally resistant, at least partially flexible, substantially radio frequency transparent cover for at least an active surface of a spacecraft antenna, which cover includes an insulating layer of fibrous, non-metallic, radio frequency transparent, insulating material, a first layer of non-conductive polymer, radio frequency transparent film on one surface of the insulating layer, which first layer is directed, in use, towards at least the active surface of a spacecraft antenna, a second layer of non-conductive, radio frequency transparent, polymer film on the surface of the insulating layer opposite to said one surface, which second layer is, or is rendered, opaque to visible and infrared radiation and is directed, in use, away from the at least the active surface of the spacecraft antenna, an electrically conductive, radio frequency transparent, coating layer on the outermost surface of the second layer, and means for electrically grounding the electrically conductive coating layer.

2. A cover according to claim 1, wherein the insulating layer is a mat of glass fibres.

3. A cover according to claim 1 or claim 2, wherein the first layer is made of a polyimide or glass fibre and quartz material.

4. A cover according to claim 3, wherein the polyimide material is KAPTON (Registered Trade Mark) and the glass fibre and quartz material is BETACLOTH (Registered Trade Mark).

5. A cover according to claim 3 or claim 4, wherein the second layer is made of a polyimide or glass fibre and quartz material rendered opaque to visible and infrared radiation by a non-conductive optically opaque paint coating layer on at least one surface thereof.

6. A cover according to claim 5, wherein the polyimide material is KAPTON (Registered Trade Mark) and the glass fibre and quartz material is BETACLOTH (Registered Trade Mark).

7. A cover according to any one of claims 1 to 4, wherein the second layer is made of polyimide material loaded with a pigment to render it opaque to visible and infrared radiation.

8. A cover according to claim 7, wherein the polyimide material is KAPTON (Registered Trade Mark).

9. A cover according to any one of claims 1 to 8, wherein the coating layer is made of Germanium or Indium-Tin Oxide.

10. A cover according to any one of claims 1 to 9, wherein the means for electrically grounding the electrically conductive layer include a plurality of strips connected to said electrically conductive layer.

11. A cover according to any one of claims 1 to 10, including means for attachment to an antenna.

12. A cover according to claim 11, wherein the attachment means are polymer studs or hook and eye tape.

13. A multilayer, thermally resistant, at least partially flexible cover for at least an active surface of a spacecraft antenna, substantially as hereinbefore described and as illustrated in Figures 1 and 2 of the accompanying drawings.

14. A cover assembly including two multi-layer thermally resistant, at least partially flexible, covers according to any one of claims 1 to 13 for covering both the active and inactive surfaces of a spacecraft antenna.

13

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number

GB 9307912.7

Relevant Technical fields

(i) UK Cl (Edition L) H1Q (QKJ,QKL,QKN), B5N

(ii) Int Cl (Edition 5) H01Q

Search Examiner

J A WATT

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASE: WPI

Date of Search

15 JULY 1993

Documents considered relevant following a search in respect of claims 1-14

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
Y	GB 2228142 A (TELEFUNKEN) whole document	1-6,9,11 and 14 at least
Y	EP 0529776 A1 (SPACE SYSTEMS) whole document	1-6,9,11 and 14 at least
Y	EP 0489531 A1 (GEC) whole document	1-6,9,11 and 14 at least
Y	US 4479131 A (HUGHES AIRCRAFT) whole document	1-6,9,11 and 14 at least

SF2(p)

1WL - doc99\fil000758

Category	Identity of document and relevant passages 14	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).